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Dagmara H. Werra[1], Richard E. Hughes[2], Marek Nowak[3], Marián Vizdal[4] and Lýdia Gačková[5]

OBSIDIAN SOURCE USE WITHIN THE ALFÖLD LINEAR POTTERY CULTURE IN SLOVAKIA

ABSTRACT

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This paper reports the results of non-destructive energy dispersive x-ray fluorescence (EDXRF) analysis of 186 obsidian artifacts from eight archaeological sites attributable to the Alföld Linear Pottery culture (c. 5600-4900 cal BC). This is the largest instrument-based study yet conducted and reported for Alföld Linear Pottery culture (ALPC) artifacts from Slovakia, where ALPC chipped lithic assemblages are almost entirely composed of obsidian items. Results show that all obsidian artifacts analyzed were manufactured exclusively from a volcanic glass of the Carpathian 1 chemical type, the source of which has been localised in Slovakia. This chemical variety of obsidian appears to have been the most important volcanic glass used by prehistoric communities in East-Central Europe during the Neolithic.

Keywords: obsidian, Alföld Linear Pottery culture, obsidian source analysis, non-destructive energy dispersive x-ray fluorescence (EDXRF), Slovakia
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[1] Institute of Archaeology and Ethnology Polish Academy of Sciences, 105, Solidarności Avenue, 00-140 Warszawa, Poland; e-mail: werra@iaepan.edu.pl; ORCID: 0000-0003-2233-1663
[2] Geochemical Research Laboratory, 20 Portola Green Circle, Portola Valley, CA 94028 USA; e-mail: rehughes@silcon.com
[3] Institute of Archaeology, Jagiellonian University, 11 Gołębia St., 31-007 Kraków, Poland; e-mail: marekiauj.nowak@ujedu.pl; ORCID: 0000-0001-7220-6495
[4] Institute of History, Prešov University, 1 17.Novembra St., 08-001 Prešov, Slovakia; e-mail: marian.vizdal@unipo.sk
[5] The Zemplín Museum, Kostolné námestie 1, 071 01 Michalovce, Slovakia; e-mail: lydia.gackova@gmail.com

INTRODUCTION

Due to its particular physical and aesthetic properties, obsidian – a natural volcanic glass – was widely used by past human communities. Its extraordinary features like gloss, colour, transparency, and razor-sharp edges, find their counterpart in its geochemical composition, where discrete combinations of trace elements created during the magma eruption and cooling allow each "source" (or, eruptive entity) to be identified. The characteristic trace and rare earth element composition, the so-called geochemical "fingerprint", of each source can be instrumentally-identified, and these can then be used for comparison with "fingerprints" determined for archaeological artefacts. The congruence between "source" and artefact fingerprints forms the scientific basis for studies of the temporal and spatial variation in the conveyance, use, and discard patterns evident in the archaeological record.

In this paper, we use energy dispersive x-ray fluorescence (EDXRF) analysis as the instrumental basis for identifying the obsidian sources used by Alföld Linear Pottery culture (ALPC) communities and discuss the results in the context of how the material may have been employed during that period.

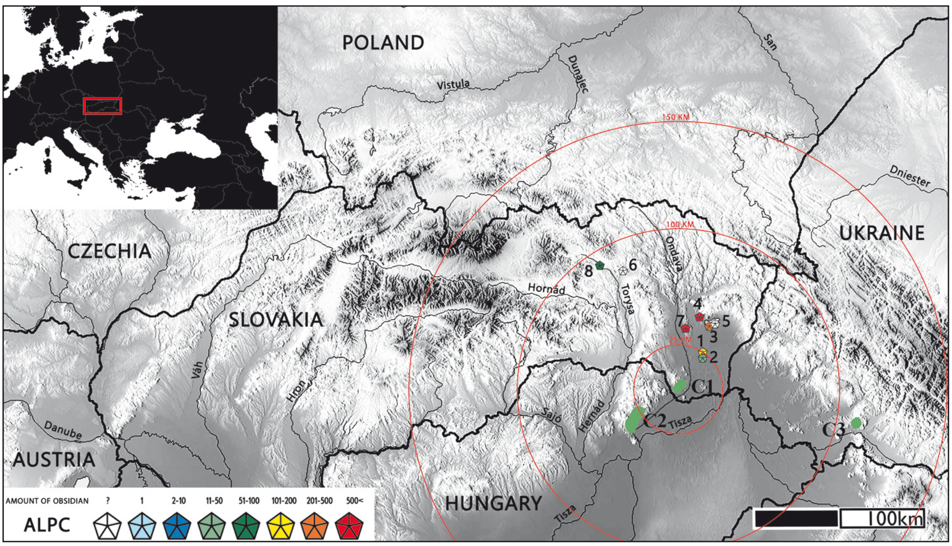

Fig. 1. Locations of ALPC archaeological sites in Slovakia containing obsidian artifacts analysed in this study. 1 – Malé Raškovce, Michalovce distr.; 2 – Slavkovce, Michalovce distr.; 3 – Zalužice, Michalovce distr.; 4 – Lúčky, Michalovce distr.; 5 – Moravany 'Stredné pole', Michalovce distr.; 6 – Zbudza, Michalovce distr.; 7 – Fintice; Prešov distr.; 8 – Ražňany-Farské, Sabinov distr.; C1 – Carpathian 1 geological obsidian outcrops; C2 – Carpathian 2 geological obsidian outcrops; C3 – Carpathian 3 geological obsidian outcrops. Red lines mark distances from Carpathian 1 source locations. Graphic design: Ł. Figura

CARPATHIAN OBSIDIAN

Several geological obsidian sources are located in, and proximate to, the Zemplén Mountains in Slovakia and Hungary (Fig. 1). Those outcrops of this material were the most important for prehistoric communities in Central Europe. By convention, obsidian raw materials are classified into three groups: Carpathian group 1 (C1) is used as a shorthand descriptor for obsidian from Slovakia, Carpathian group 2 (C2) identifies obsidian from Hungary, and Carpathian group 3 (C3) specifies material from Transcarpathian Ukraine (Thorpe *et al.* 1984; Rosania *et al.* 2008).

The occurrence of obsidian in what is today Slovakia and Hungary was first noted by Johann Ehrenreich von Fichtel (1732-1795) in 1791 (*Mineralogische Bemerkungen von den Karpathen*, Wien 1791-1794; Janšák 1935; Přichystal 2013, 160). Within Slovakia natural sources of obsidian are concentrated in Veľká Tŕňa, Malá Tŕňa, Viničky, Malá Bara, Vel'ká Bara and Streda nad Bodrogom, and secondary sources are known in the area of Brehov-Cejkov (Kaminská and Ďuďa 1985, 123; Kaminská 1991; 2013; 2018; Bigazzi *et al.* 2000, 225; Přichystal 2013, 160, 161; Přichystal and Škrdla 2014; Bačo *et al.* 2017, 208).

The best-known outcrop, and the one frequently cited as being most important to prehistoric communities, is in Viničky. This deposit has been described by O. Williams and J. Nandris (1977, 216), and its major and minor element composition appears in Macdonald *et al.* (1992, appendix 3, 189, 196). The obsidian there is either black or grey and poorly transluscent, with a matte surface. This raw material is found in primary deposits yielding nodules *c.* 7 cm in diameter, rarely 10-12 cm weighting up to 0.8 kg (Williams and Nandris 1977, 211; Přichystal 2013, 160). However, based on recent comparisons between obsidian artefacts and obsidian from the sources Přichystal and Škrdla (2014) suggest that the Brehov-Cejkov may have been the most important locus for prehistoric obsidian extraction (Bačo *et al.* 2017; Burgert *et al.* 2017, 8-10).

Three geological sources of obsidian occur in northeastern Hungary – Tolcsva, Erdobenye-Aranyospatak and Erdobenye-Ligetmajor (Biró 1981, 201; Přichystal 2013, 161), with obsidian present as nodules weighing over 5 kg. This obsidian is generally black in appearance, but it can also be found in a variety of different hues, such as dark brown, greenish, light red, reddish-brown, yellow, and yellowish-green. The most well-known variety is the obsidian from Tolcsva which is opaque, matt, and black (Williams and Nandris 1977, 213; Přichystal and Škrdla 2014, 161). The major and minor element chemistry of Tolcsva also was reported by Macdonald *et al.* (1992, appendix 3, 189, 196).

Some time ago O. W. Thorpe, S. E. Warren, and J. G. Nandris (1984, 184), pointed out that there are visible differences in colour and transparency that differentiate Hungarian obsidian from that found in Slovakia; the Hungarian variant is almost always black and opaque, while its Slovakian counterpart can be grey or brownish-grey, with some degrees of transparency (Přichystal 2013, 161). The discovery of a new visual variant of obsidian by Přichystal and Škrdla, however, throws into question the confidence one can have that these visual intrasource differences unambiguously separate Hungarian from Slovakian occurrences.

In the Transcarpathian Ukraine, not far from the villages of Rokosovo and Maliy Rakovets, V. F. Petrougne (1986) reported a local variety of obsidian that eventually became known as Carpathian 3 (Rosania *et al.* 2008; Hughes and Ryzhov 2018). To the north of Rokosovo and the south of Maliy Rakovets in the Upper Tertiary Sin'ka Formation, obsidian blocks and bombs occur in an agglomerate tuff. This obsidian has two visual subtypes: a freshly broken piece of the first variety has a glassy lustre and, occasionally, displays unique grey stripes. The second type is grey, with a dull sheen, is striped with darker bands and contains visible spherulite inclusions. These latter characteristics are very rarely noticeable within the first black variation (Rácz 2018).

MATERIALS

This paper focuses on EDXRF provenance analysis of 186 obsidian artefacts from eight Neolithic sites located within what is today Slovakia (Fig. 1; Table 1). We chose artifacts from sites associated with the activity of ALPC communities from each of its chronological phases, including the last stage connected with the Bükk culture. All materials analysed were selected from properly dated settlements with large quantities of pottery and with ^{14}C dates. With the exceptions of Lúčky and Fintice (Vizdal 2000a; 2000b), the results of archaeological investigations of the sites that we examined have all been published (see Table 1).

GENERAL REMARKS ON TECHNOLOGY-MORPHOLOGY AND LITHIC SOURCES CHARACTERIZATION OF THE ALPC IN SLOVAKIA

In the middle of the 6th millennium in the area of the middle and upper Tisza Basin the ALPC came into being as a result of northward expansion of the Körös culture and its regional, cultural transformations. Afterwards, the scientific consensus seems to be that those communities diffused northward from the Great Hungarian Plain to the Košice Basin, the Eastern Slovak Plain, and the Transcarpathian Ukraine, but the expansion never crossed the Carpathian Mountains (Kalicz and Makkay 1966; 1977; Šiška 1989; Pavúk 2004, 74; Kozłowski and Nowak 2007; 2010; Domboróczki and Raczky 2010).

The earliest ALPC expression (Szatmár group, equivalent to the so-called proto-Linear phase in eastern Slovakia) is dated to the period *c.* 5600-5400 cal BC (Domboróczki 2010, 156-161; Domboróczki and Raczky 2010, 213-215). In sites of this phase, the lithic resources used are nearly always of local origin, mostly obtained in the Slovak-Hungarian borderland (limnoquartzites, and Carpathian obsidian 2) and Transcarpathian Ukraine (predominantly the stone used in the ground stone industry). Some imports of radiolarite from Šariš are recorded (Slavkovce site) in the Eastern Slovak Lowland during the early ALPC phase but, overall, there is very little evidence for contacts with territories to the north and the east of the Carpathians (Kozłowski 1997; Kozłowski and Nowak 2010; Raczky *et al.* 2010; Kozłowski *et al.* 2014, 42-45).

The typical assemblage composition of ALPC sites throughout most of the Eastern Slovak Lowland consists of obsidian (dominant), with lower proportions of limnoquartzites, radiolarite, and others (*e.g.* hornstornes at Moravany). Except for "others", all of those sources can be found within several dozen kilometres from the site (< 50 km distant up to 120 km; Kozłowski and Nowak 2010, 76, 86; Kaczanowska *et al.* 2013, 113, 114; Kaczanowska *et al.* 2015, 172). Evidence of long-distance contacts in lithic sources occurs only rarely. For example, two artefacts recovered at Moravany were of chocolate flint (Upper Jurassic, the highest Oxfordian limestone and Lower Kimmeridgian, located within Central Poland) and the other of Volhynian flint (Cretaceous flint Turonian age; primary deposits located within the Volhynian Upland; Kozłowski 1989, 378, 391; Kaczanowska and Kozłowski 1997, 221; Kozłowski and Nowak 2010, 76, 86; Kaczanowska *et al.* 2013, 112-114; 2015, 172).

Unmodified obsidian nodules are often found on these sites; *e.g.* Slavkovce contained a cache of 34 obsidian nodules (see Kaczanowska and Kozłowski 1997, 184). Direct percussion and pressure techniques were mostly used to obtain blade blanks. There is some evidence that in younger ALPC assemblages a punch was used. Cores preparation was limited to platform preparation, and did not extend to the lateral side, back and distal end. It seems that core reduction proceeded from a prepared platform and during the manufacturing process, the flaked surface was extended to the sides of the core, until a conical, semi-conical or subdiscoidal form was achieved. Single platform blade cores predominate, except during the last phase when the method of reduction was changed and the object became a flake core. Flaking surface rarely extends over the lateral edges. Flakes were derived from cortical platforms or prepared with a single blow. Percussion points and bulbs are conspicuous, and percussion scars on the bulb indicate that hard hammerstones were used for core reduction. Blades also have platforms prepared with a single blow, and the distinctive bulb and bulbar scar also are consistent with the use of the direct percussion technique. Based on lithic analysis, the most desired end products were obsidian blades of dimensions: 30-40 mm long, 15-15 mm wide and 3-4 mm tick. Tool-kits were mainly composed with different proportions of retouched blades, retouched flakes, end-scrapers and geometric microlithic, which reflect the different domestic economic activities undertaken by the inhabitants of various settlements (Kozłowski 1989, 391; Kaczanowska and Kozłowski 1997, 178-180, 188, 189, 191, 194, 195, 220; Kaczanowska *et al.* 2013, 112; 2015, 173, 175). The Bükk culture assemblages contain large numbers of cores and blades. Cores are single-platform and their exploitation was preceded by careful preparation, as evidenced by technical forms, like crested blades. The pressure technique was used to obtain blade blanks, mainly up to 5 cm long. Most tools produced however, were end-scrapers and truncations with lateral retouch and notched forms. Tool-kit composition appears to be related to site function rather than to time period. It is commonly stated that the Bükk culture lithic economy was built only on obsidian (Kulczycka and Kozłowski 1960, 44; Kalicz and Makkay 1977), but the evidence from *e.g*. Šarišské Michaľany and Ražňany-Farské indicate this was not always the case (Kaczanowska *et al*. 1993, 95, 107-109; Karabinoš *et al*. 2018). Obsidian played a major role at settlements at a distance around 55 km from the outcrops. The amount of obsidian utilized appears to have depended not only on the site location but the different domestic economic activities that took place there.

PREVIOUS PROVENANCE INVESTIGATIONS

Over the last few decades since the first description of Carpathian obsidians, numerous modern analytical methods have been applied to determine the provenance of obsidian artifacts (see e.g. Biró 2006; Rózsa *et al*. 2006; Kasztovszky *et al*. 2014; Prokeš *et al*. 2015; Kasztovszky and Přichystal 2018).

However very little instrumental analysis has been undertaken on obsidian from ALPC sites. Kozłowski published results of the trace elements analysis of some obsidian samples from Zemplínske Kopčany and Prešov-Šarišské Lúky (Kozłowski 1989, Tab. 2), wherein all the analysed items were attributed to Carpathian obsidian type 1, from the Malá Tŕňa-Viničky region (Kozłowski 1989, 377). The results show a high degree of homogeneity suggesting that the raw material must have been obtained from a single eruptive source.

The obsidian raw material at Moravany – which was imported most probably as unworked nodules with surface sculpture typical of secondary (redeposited) natural sources – was determined to be Carpathian variety 2 obsidian by Małgorzata Kaczanowska on the basis of macroscopic appearance (Kaczanowska *et al*. 2015, 172; see Bačo *et al*. 2017, 209).

METHODOLOGY

As stated above, a study of the provenance of 186 artifacts of obsidian from 8 archaeological sites was conducted (see Table 2). The first step of selection was macroscopic. In this stage, samples were separated on the basis of differences in lustre, transparency and colour, as well as texture and pattern in obsidian structure (Fig. 2). We also paid attention to the size of all items and surface sculpture, keeping in mind the features of Carpathian obsidian identified by Přichystal and Škrdla (2014) and by Bačo *et al*. (2017; 2018). Table 2 breaks down the artifacts analysed in this study on the basis of a classification intended to document the presence of obsidians items in each stage of the lithic reduction (see Dzieduszycka-Machnikowa and Lech 1976; Lech 2012). The first group (natural nodules

Fig. 2. Obsidian artifacts analysed in the present study: a-h – Moravany 'Stredné pole', Michalovce distr.; i-l – Zbudza, Michalovce distr.; m-o – Slavkovce, Michalovce distr.; p, q – Ražňany-Farské, Sabinov distr.; r, s – Fintice; Prešov distr.; t-v – Malé Raškovce, Michalovce distr.; w, x – Zalužice, Michalovce distr.; y-b' – Lúčky, Michalovce distr.; Photo: D.H. Werra

and cores) contains 24 items; seven unworked (natural) obsidian nodules, roughouts in different stages of preparation, and 17 cores in different stages of reduction. The second group consists of ten whole blades and 44 blade fragments. The other three specimens are technical blades. The third group of 77 artifacts is made up of flakes and waste, along with platform rejuvenation and preparation flakes. The fourth and final group (retouched tools) consisted of 28 artifacts, mostly end-scrapers together with retouched blades and flakes. We used these groups to guide our selection of obsidian artifacts for EDXRF analysis to investigate whether or not some elements of the obsidian lithic reduction system (of which there were distinctive types in each morphological group) might have employed obsidian from different sources (chemical types).

GEOCHEMICAL ANALYSIS AND RESULTS

The 186 samples selected for this study were analysed in the Geochemical Research Laboratory in California using EDXRF spectrometry and assigned to a geochemical type/variety and therefore a source (*sensu* Hughes 1998). Laboratory analysis conditions, instrumentation, geochemical type attribution procedures, element-specific measurement

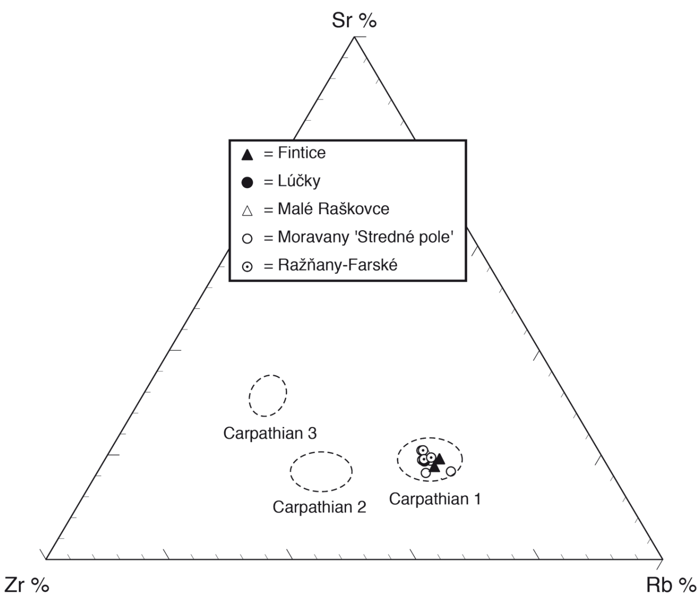

Fig. 3. Normalized Rb/Sr/Zr composition of small obsidian artifacts from Fintice, Lúčky, Malé Raškovce, Moravany 'Stredné pole' and Ražňany-Farské. Dashed lines depict the range of composition variation measured in archaeologically significant geological reference samples. (adapted from Hughes and Werra, 2014: figure 5). Symbols plot the artifacts listed in Table 4

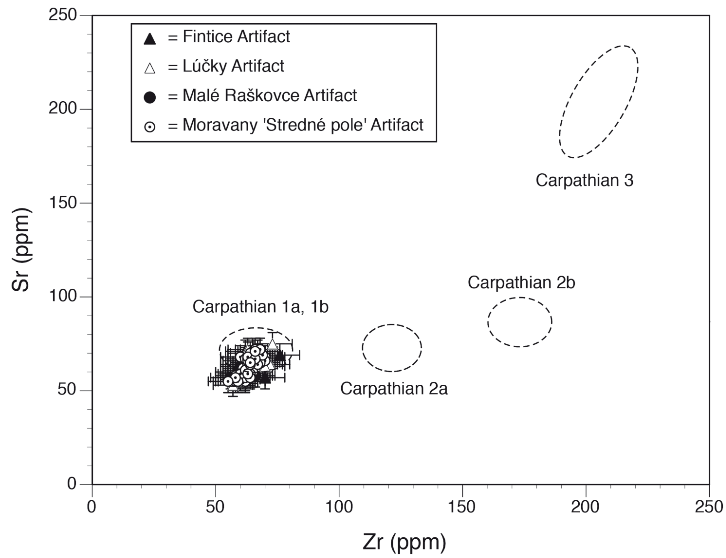

Fig. 4. Sr vs. Zr composition of large obsidian artifacts from Fintice, Lúčky, Malé Raškovce, Moravany 'Stredné pole'. Dashed lines depict the range of composition variation measured in archaeologically significant geological reference samples (adapted from Hughes and Werra, 2014: figure 4). Symbols plot the artifacts listed in Table 3

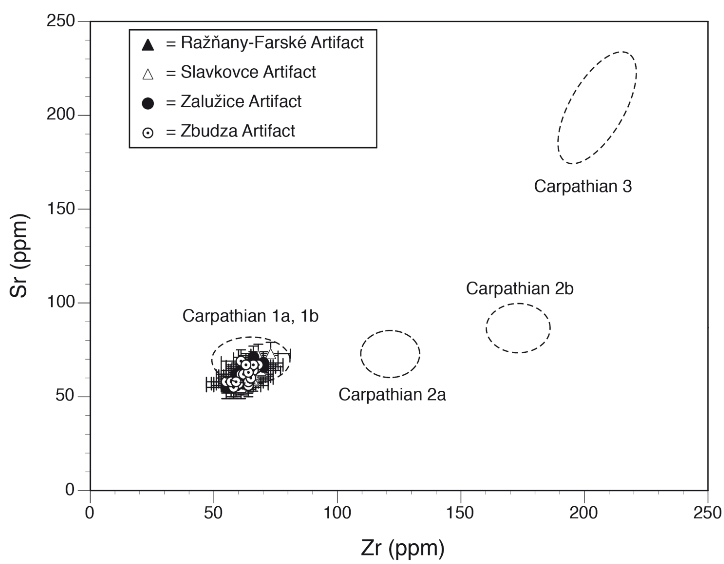

Fig. 5. Sr vs. Zr composition of large obsidian artifacts from Ražňany-Farské, Slavkovce, Zalužice and Zbudza. Dashed lines depict the range of composition variation measured in archaeologically significant geological reference samples (adapted from Hughes and Werra, 2014: figure 5). Symbols plot the artifacts listed in Table 3

resolution, and literature references applicable to these samples follow those that we reported for artifacts from Ryndo XIII/1959 (Hughes and Werra 2014) and from other Mesolithic and Paleolithic sites in Poland (Hughes *et al*. 2018). Table 3 and Fig. 4-5 present trace element concentration values for the 174 obsidian artifacts that were large enough to generate reliable quantitative composition estimates. The Sr/Zr data for all specimens plotted within the range established for Carpathian 1a/1b obsidians (Rosania *et al*. 2008, Milić 2014, Table 6), that occur in the Zemplén Mountains in northeast Hungary and southeast Slovakia (Fig. 3 and 4). Twelve other obsidian specimens in our sample were too small and thin to generate x-ray counting statistics adequate for proper conversion from background-corrected intensities to quantitative concentration estimates (*i.e*., ppm), so they were analysed to generate integrated net count (intensity) data for the elements Rb, Sr, Y, Zr, Nb, Fe and Mn. After background subtraction, the intensities (counts per second) were converted to percentages. The counting data and derived ratios appear in Table 4, and the plotted values appear in Fig. 3. Source assignments were made by comparing the plots for various element intensity ratios determined on artifacts against the parameters of known source types identified in Central Europe. Integrated net peak intensity data (Table 4, Fig. 3) indicate that all 12 small flakes also were manufactured from Carpathian 1a/1b obsidian. The EDXRF analysis did not reveal any source-specific differences within or among different ALPC morphological or typological groups.

DISCUSSION AND CONCLUSIONS

Obsidian artefacts are present on archaeological sites in Slovakia dated from the Middle Palaeolithic, through the Upper Palaeolithic, Mesolithic, Neolithic, up to the Early Bronze Age. However as Early Neolithic communities began to appear in Slovakia, the incidence of obsidian use increased (Kaczanowska 1985; Kaminská 2018). The ALPC inventories, for example, are almost entirely composed of obsidian items.

Almost 100% utilization of obsidian was registered at some sites (*e.g*. Zbudza, Zalužice, Slavkovce and Malé Raškovce). At Moravany, obsidian makes up almost 90% of the industry (Kozłowski 1989; Šiška 1989; Kaczanowska and Kozłowski 1997, 220, 221; Kaczanowska *et al*. 2015), while in the following Tiszadob group utilization of obsidian represented almost a half of all finds (Kaminská *et al*. 2016). In the following Bükk culture, obsidian dominates the entire chipped stone lithic industry. However in the material that we present here from the inventory from Ražňany-Farské obsidian does not conform to this pattern (Karabinoš *et al*. 2018, 348), nor does it at the Šarišské Michaľany site (Kaczanowska *et al*. 1993).

Obsidian was subject to conveyance and long-distance distribution since Palaeolithic times (see Moutsiou 2014; Hughes *et al*. 2018) and, during the Neolithic, these activities intensified. Volcanic glass artifacts are present in inventories connected with Linear Pottery culture sites (especially in the Želiezovce group), in western Slovakia, in southern Poland, and in ALPC assemblages in eastern Slovakia and Hungary (Kulczycka and Kozłowski 1960; Godłowska 1982; Milisauskas 1986; Šiška 1998; Grygiel 2004; Kaczanowska and Godłowska 2009; Szeliga 2009; Tunia 2016; Biró 2018; Kaminská 2018; Riebe 2019; Szeliga *et al.* 2019a; 2019b). Even higher demand for obsidian seems to have existed during the Late Neolithic (following the decline of the Bükk culture, during the beginning of the Lengyel culture), when raw material exchange and conveyance moved semi-products and finished products of obsidian as far as the central Danube region (Šiška 1989, 77), Czechia (Burgert 2015; Burgert *et al.* 2016; 2017), Poland, and the Polish Lowlands (Więckowska 1971; Kabaciński 2010; Wilczyński 2016). At the end of the Neolithic and during the Eneolithic period obsidian lost its dominant status, although it has been found occasionally in Early Bronze Age deposits (Biró 2014, 60-64; 2018, 219-222; Kaminská 2018, 209).

Based on our current study it is clear that the obsidian artefacts from the ALPC archaeological in eastern Slovakia sites that we analysed originated exclusively from the Carpathian obsidian source (chemical type) C1 (see Fig. 3-5; Table 3 and 4). These results parallel those from neighbouring countries. Investigations in Czechia and Hungary show that the Slovakian variant predominates at Neolithic sites, with a minor representation of the C2 variant (Biró 2014; 2018; Burgert *et al.* 2016; 2017; Riebe 2019). A similar situation seems to have existed in Romania (Constantinescu *et al.* 2014, 148), although at some sites the Hungarian variant of obsidian predominates (*i.e.* Măgura-Teleorman; Kasztovszky *et al.* 2019, 86). The limited geochemical analysis previously conducted on Neolithic obsidian from Poland also indicates the exclusive dominance of the C1 obsidian variant (Kabaciński *et al.* 2015; Szeliga *et al.* 2019a; Szeliga *et al.* 2021). Obsidian of the Carpathian 1 chemical type seems to have been the most important volcanic glass for prehistoric communities in East-Central Europe (Biró 2014, 64, Fig. 13), and this is underscored by the results of our study.

The tracing of the origins of the obsidian used for tools is a success story in Central European lithic provenance studies (Biró 2014, 47). Thanks to its unique geochemical features ('fingerprints') different chemical varieties can be distinguished by using instrumental methods. Such identifications allow us to analyse sources and uses, and to track synchronic and diachronic changes in distribution paths and conveyance mechanisms. Determining the sources is just one step in piecing together the puzzle (Biró 1998; Tykot 2017, 274) with the ultimate goal of understanding the complex interrelationships that existed between and among prehistoric communities. Carpathian obsidian is found in Neolithic site inventories at a considerable distance from the outcrops (even over 500 km; for example Kowalewko site 14, Oborniki dist., Kabaciński *et al.* 2015), and its presence can be useful in identifying such human connectivities, as well as possible differences in status, social rankings, and symbolic links to homeland/ancestors (see Mateiciucová 2010; Burgert 2016). We hope the data and conclusions presented here will contribute to a broader understanding of all these issues during the Neolithic period.

Table 1. List of ALPC sites from Slovakia from which samples were analysed

Fig. 1 location	Site	Chronology	Total number of obsidian at the site	Number of items from other lithic sources	Number of obsidian analyzed by ED-XRF	References
1	Malé Raškovce; Michalovce distr.	early phase of the ALPC (proto-Kopčany group?)	25	4	20	Kozłowski 1997
2	Slavkovce; Michalovce distr.	proto-linear phase, similarity to Szatmár II group of the ALPC	167	8	20	Kozłowski 1997
3	Zalužice; Michalovce distr.	early phase of the ALPC (proto-Kopčany group?)	261	112	20	Kozłowski 1997
4	Lúčky; Michalovce distr.	ALPC middle and late phase (Tiszadob group)	?	?	20	Vizdal 2000a
5	Moravany 'Stredné pole'; Michalovce distr.	ALPC, the whole period *ca.* 5600-5100 BC	3904	486	58	Kaczanowska *et al.* 2015; Kozłowski *et al.* 2015
6	Zbudza; Michalovce distr.	early phase of the ALPC (proto-Kopčany or Kopčany group)	887	91	20	Kozłowski 1997
7	Fintice; Prešov distr.	ALPC middle and late phase (Tiszadob group)	?	?	20	Vizdal 2000b
8	Ražňany-Farské; Sabinov distr.	Bükk culture (continue from ALPC, its final stage)	60	1467	8	Karabinoš *et al.* 2018
TOTAL			5316	2248	186	

Table 2. List of obsidian artifacts from Neolithic archaeological sites in Slovakia analysed by EDXRF spectrometry

No.	Site	Feature	length (mm)	width (mm)	thickness (mm)	weight (g)	description	EDXRF analysis number	Illustrated
1			80,8	46,9	42,9	279,3	nodule	SK-081	
2			115,7	48,4	37	213,9	nodule	SK-082	Fig. 2:m
3			31,7	22,8	20,5	18,8	nodule fragm.	SK-083	
4			20,7	35,1	5,5	3,3	flake	SK-084	
5			34,5	20,1	3	2,4	flake	SK-085	
6			13,3	21,5	2,5	0,7	waste	SK-086	
7			43	24,5	5	8,6	flake	SK-087	
8			27,9	38,2	8,5	6,6	retouched blade	SK-088	
9			26,4	32	3,8	2,4	flake	SK-089	
10	Slavkovce, Michalovce distr., Slovakia	Feature E/1988	46	17	21,5	23,8	core	SK-090	Fig. 2:n
11			36,2	21,4	20,9	15,9	core frgm.	SK-091	
12			25	38	4	2,8	platform rejuvenation flake	SK-092	
13			33	27	4	6,6	flake	SK-093	
14			23,8	41,9	8,2	7,1	flake	SK-094	
15			43,3	28,5	12,4	11,6	retouched blade	SK-095	
16			17,4	21,7	3,4	1,7	backed piece	SK-096	Fig. 2:o
17			27,6	16,8	4,8	2,4	retouched blade	SK-097	
18			21,5	27,8	7,5	4,5	waste	SK-098	

Table 2.

No.	Site	Feature	length (mm)	width (mm)	thickness (mm)	weight (g)	description	EDXRF analysis number	Illustrated
19	Slavkovce, Michalovce distr., Slovakia	Feature E/1988	54,6	42,4	13,2	30,5	flake	SK-099	
20			27,8	28,1	6,2	4,7	end-scraper	SK-100	
21	Malé Raškovce, Michalovce distr., Slovakia	Feature 1/1988	63,5	57,9	18,5	58,7	platform rejuvenation flake	SK-121	
22			23	18,6	4,9	2,8	blade fragm.	SK-122	
23			29,7	6,3	1,9	0,3	blade fragm.	SK-123	
24			26,8	13,4	2,1	1,1	blade fragm.	SK-124	
25			32,6	13,5	2,9	1,5	retouched blade	SK-125	Fig. 2:t
26			31,8	27,6	9,9	7,2	platform rejuvenation flake	SK-126	
27			34,1	13,7	4	1,8	blade	SK-127	
28			31,7	15,9	6	3,3	retouched blade	SK-128	
29			35,8	40,5	7,7	13,6	flake	SK-129	Fig. 2:u
30			36	15,2	6,3	3,6	retouched blade	SK-130	
31			28	12,5	3,7	1,3	blade fragm.	SK-131	
32			30,2	30	9	7,4	flake	SK-132	
33			39,5	12	7,7	3,5	blade fragm.	SK-133	
34			20	25	19,8	9,3	core	SK-134	
35			30,3	21,5	6,8	5	retouched blade	SK-135	

36	Malé Raškovce, Michalovce distr., Slovakia	Feature 1/1988	17,3	28,8	28	17,6	core	SK-136	
37			48,6	15	7,1	4,3	retouched blade	SK-137	
38			36,7	17,2	6,4	4	retouched blade	SK-138	Fig. 2:v
39			23	24,6	7	4,1	platform rejuvenation flake	SK-139	
40			33	14	4,5	2,2	blade	SK-140	
41	Zalužice, Michalovce distr., Slovakia	Feature 1/1991	24	24,4	4	2,3	flake	SK-141	
42			30,7	33,1	12,5	12,1	waste	SK-142	
43			51,7	33,2	8,5	10,6	flake	SK-143	
44			39,7	14	3,5	2,1	retouched blade	SK-144	
45			44,4	40	8,7	16,6	waste	SK-145	
46			26,3	18,6	4,6	1,7	flake	SK-146	
47			23,2	16	4,3	1,6	blade fragm.	SK-147	Fig. 2:w
48			41,3	27	16,1	6,2	platform rejuvenation flake	SK-148	
49			15,8	13	6,3	1,3	waste	SK-149	
50			30,7	19,4	9,3	5,5	preparation flake	SK-150	
51	Zalužice, Michalovce distr., Slovakia	Feature 2/1994	26,6	15,7	3,2	1,1	flake	SK-151	
52			28,7	11,2	3,3	1,1	blade	SK-152	Fig. 2:x
53			20,3	20,7	6,7	3	end-scraper	SK-153	
54			29,9	19,2	5,8	2,9	blade fragm.	SK-154	

Table 2.

No.	Site	Feature	length (mm)	width (mm)	thickness (mm)	weight (g)	description	EDXRF analysis number	Illustrated
55	Zalužice, Michalovce distr., Slovakia	Feature 2/1994	45,7	45,2	16,5	20,3	flake	SK-155	
56			51,4	14,2	4,3	4,6	blade	SK-156	
57			23	21,6	2,9	1,2	flake	SK-157	
58			37,1	23,2	4,3	4,9	flake	SK-158	
59			30	17,7	3	2,1	blade fragm.	SK-159	
60			24,6	14,6	9,2	2,2	waste	SK-160	
61	Zbudza, Michalovce distr., Slovakia	Feature 1/1992	24,3	11,8	2,6	0,9	platform rejuvenation blade	SK-101	
62			28,7	16,6	9	2,6	preparation flake	SK-102	
63			18,8	13,3	3,1	0,9	platform rejuvenation flake	SK-103	
64			15,3	29	5,5	2	flake	SK-104	
65			16,7	13,4	2,9	1,4	retouched blade	SK-105	Fig. 2:i
66			20,6	13,1	3,6	0,9	retouched blade	SK-106	
67			17,7	24,7	4,6	1,8	blade fragm.	SK-107	
68			17,4	29,9	9,5	3,5	flake	SK-108	
69			22,9	16,8	6,5	3	blade fragm.	SK-109	
70			20,2	22,8	4,5	1,8	flake	SK-110	
71			26,3	22,2	7,3	4,7	crested blade	SK-111	

72	Zbudza, Michalovce distr., Slovakia	Feature 1/1992	27,9	14,4	14,6	5,6	flake	SK-112	Fig. 2:j
73			28,9	16	9,3	3,2	waste	SK-113	
74			24,4	37,9	9,8	11,4	flake	SK-114	Fig. 2:k
75			31,2	35,6	14,3	13,2	waste	SK-115	
76			32,8	14,6	4,5	2,4	blade fragm.	SK-116	Fig. 2:l
77			15,8	17,7	6,7	2,3	blade fragm.	SK-117	
78			42,6	15,8	3,8	2,8	retouched blade	SK-118	
79			15,9	16,5	5,2	1,6	retouched blade	SK-119	
80			24,6	10,9	4,9	1,5	blade fragm.	SK-120	
81	Lúčky, Michalovce distr., Slovakia	Feature 1/1999, Trench A, B, C; depth 0-30 cm	16,9	29	5,2	2	waste	SK-161	
82			36,3	16,1	5,5	3,2	retouched blade	SK-162	
83			30,6	9,4	1,7	0,6	blade fragm.	SK-163	
84			29,6	8,9	2,5	0,7	retouched blade	SK-164	Fig. 2:y
85			33,8	12,8	3,6	1,7	blade	SK-165	
86			24,1	15,6	3,3	1,3	blade fragm.	SK-166	Fig. 2:z
87	Lúčky, Michalovce distr., Slovakia	Feature 1/1999, Trench A; depth 20-30 cm	26,1	19,3	3	1,5	retouched flake	SK-167	
88			28	20	3,3	1,8	flake	SK-168	
89	Lúčky, Michalovce distr., Slovakia	Feature 1/1999, Trench A; depth 10-15 cm	29,5	17,1	4	1,7	flake	SK-169	Fig. 2:a'
90			47,4	19,9	5,2	5,2	retouched blade	SK-170	Fig. 2:b'
91			25,3	28,1	13	10,5	core	SK-171	
92			29,8	13	2,6	1,2	blade fragm.	SK-172	

Table 2.

No.	Site	Feature	length (mm)	width (mm)	thickness (mm)	weight (g)	description	EDXRF analysis number	Illustrated
93	Lúčky, Michalovce distr., Slovakia	Feature 1/1999, Trench A; depth 10-15 cm	21,7	16,8	3,4	1,2	blade fragm.	SK-173	
94			31,5	10,8	3,1	0,9	blade fragm.	SK-174	
95			31,2	26,7	7,5	6,7	platform rejuvenation flake	SK-175	
96	Lúčky, Michalovce distr., Slovakia	feature 1/1999, sonda C; depth 0-10 cm	12,3	9,2	3,5	0,3	waste	SK-176	
97			29,3	10,6	3,7	1,3	blade fragm.	SK-177	
98	Lúčky, Michalovce distr., Slovakia	Feature 1/1999, Trench C; depth 0-10 cm	42,7	38,5	8,1	8,8	flake	SK-178	
99			35,2	21,9	3,7	3,3	blade fragm.	SK-179	
100			23,1	13,7	3,1	1,1	blade fragm.	SK-180	
101	Fintice, Prešov distr., Slovakia	Feature 1/1999	32	10,8	2,5	1,2	blade fragm.	SK-061	Fig. 2:r
102			31,5	17	5,3	3,9	retouched blade	SK-062	
103			42	16	5	4	blade fragm.	SK-063	
104			21,5	20	4,6	1,9	platform rejuvenation flake	SK-064	
105			18	8,4	4,5	0,6	waste	SK-065	
106			40,1	17,8	4,7	4,4	blade fragm.	SK-066	Fig. 2:s
107			38,3	34,9	30,6	34,9	core	SK-067	
108			21,4	14,7	4,7	1,2	flake	SK-068	
109			20,9	27,9	1,5	0,9	waste	SK-069	

110	Fintice, Prešov distr., Slovakia	Feature 1/1999	31,5	19,5	10,9	8	nodule fragm.	SK-070	
111			20,9	25,5	6,7	2,6	end-scraper	SK-071	
112			22	18	3	2,2	blade fragm.	SK-072	
113			17,8	11,4	1,5	0,2	blade	SK-073	
114			19	8,7	5,5	0,7	waste	SK-074	
115			10,3	12,5	1,3	0,2	waste	SK-075	
116			28,7	12,8	3	1,3	waste	SK-076	
117			27,3	12,7	5,7	1,7	retouched blade	SK-077	
118			36,7	13,9	4,4	2,7	blade fragm.	SK-078	
119			12,5	17,8	6,2	1,5	end-scraper	SK-079	
120			41,2	13,2	3,5	2,2	blade fragm.	SK-080	
121	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench M; Cutting 11/2016, Feature 1/06(A)/W; E - 306 cm; S - 177 cm; depth 85-95 (- 220 cm)	36	35	19	23,5	pre-core	SK-001	
122			24,5	7	2	0,4	blade	SK-002	
123			30,6	19,7	5,1	3,5	platform rejuvenation flake	SK-003	
124			16,6	10,9	2,2	0,5	blade fragm.	SK-004	
125			18,8	12,6	3,3	0,7	flake	SK-005	
126			37,5	26,8	12,7	11,9	nodule fragm.	SK-006	
127			45	22,1	14	10,2	nodule fragm.	SK-007	
128			12,5	9,5	3	0,3	blade fragm.	SK-008	
129			36,3	34,7	13,5	18,5	core	SK-009	

Table 2.

No.	Site	Feature	length (mm)	width (mm)	thickness (mm)	weight (g)	description	EDXRF analysis number	Illustrated
130	Moravany 'Stredné pole', Michalovce distr., Slovakia	layer 0-40 cm (depth); next to Feature 4/2002 (07.2002)	41,2	25,7	12	13,3	core	SK-010	
131	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench F; Cutting 3/2001 part S; Feature 3/01, depth 70 cm; 22.07.2002	22,5	14	3	1	blade fragm.	SK-011	
132			12,4	8,8	3	0,4	blade fragm.	SK-012	
133			22,5	9,5	3	1,1	blade	SK-013	
134			19,1	12,9	2,9	0,6	flake	SK-014	
135			38,6	35,7	6,6	5	flake	SK-015	
136	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench F; Cutting 2B/2001; Feature 10/01, depth 20-40 cm; 10.07.2002	31,5	23,3	15,2	8,1	flake	SK-016	
137			23	18,2	8,2	3,6	blade fragm.	SK-017	
138	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench 11; Cutting 12/2006; depth 20-25 cm; 16.07.2006	16,8	11,5	5,5	1	waste	SK-018	
139			26,2	16,2	4,2	1,9	flake	SK-019	
140			7,8	7,2	2,2	0,1	waste	SK-020	
141			18,7	13	5,5	1,1	flake	SK-021	
142			39,3	32,8	16,7	22,9	nodule fragm.	SK-022	
143	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench H; Cutting 4/2002; Feature 4/02; 22.07.2002	50	26,3	43,2	53,3	core	SK-023	Fig. 2:a
144			10,4	7,4	2,5	0,1	waste	SK-024	
145			24,7	19,7	4,8	2,1	flake	SK-025	

146	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench H; Feature 4/02; 24.07.2002	24,3	23,3	6,8	3,6	blade fragm.	SK-026	Fig. 2:c
147			16,9	17,7	5	1,8	blade fragm.	SK-027	
148	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench F; Cutting 2B/2001; Feature 10/01, depth 40-50 cm; 17.07.2002	29,5	14,5	4	1,3	blade fragm.	SK-028	
149			8,2	11,2	3,2	0,3	blade fragm.	SK-029	
150			14	20,5	7,8	1,7	waste	SK-030	
151			16	18,7	4,4	1,1	waste	SK-31	
152			47,7	31,7	18,2	37,9	core	SK-032	Fig. 2:b
153			17,5	14,4	3	1,1	backed piece	SK-033	
154	Moravany 'Stredné pole', Michalovce distr., Slovakia	Feature 1/1998; sector C; September 1998	14	17,5	4,5	2,1	flake	SK-034	
155			22,7	26,5	7,5	4,1	waste	SK-035	
156			26,7	25,3	7,5	4	flake	SK-036	Fig. 2:d
157			21,2	21,2	6	2,3	flake	SK-037	
158			16,4	12,7	2,1	0,5	flake	SK-038	
159			25,7	27	5,9	1,9	waste	SK-039	
160			30,2	29,9	4,9	3,7	platform rejuvenation flake	SK-040	Fig. 2:e
161			24,8	15,2	7,8	2,5	blade fragm.	SK-041	
162			18,1	16,5	5,7	1,4	flake	SK-042	
163			25,7	12,1	7,9	1,6	waste	SK-043	
164	Moravany 'Stredné pole', Michalovce distr., Slovakia	Feature 1/1998; sector A; September 1998	26,8	28,4	10,1	8,2	core frgm.	SK-044	
165			36,7	18,8	9,9	6	overpassed blade from single platform core	SK-045	

Table 2.

No.	Site	Feature	length (mm)	width (mm)	thickness (mm)	weight (g)	description	EDXRF analysis number	Illustrated
166	Moravany 'Stredné pole', Michalovce distr., Slovakia	Feature 1/1998; sector A; September 1998	33,9	25,1	17,5	16,3	core frgm.	SK-046	
167			32	36	16,9	18,8	core frgm.	SK-047	
168			37	32,8	32,1	37,6	core	SK-048	
169	Moravany 'Stredné pole', Michalovce distr., Slovakia	Feature 1/1998; sector A; September 1998	53	13	5	3,4	blade fragm.	SK-049	
170			39,8	17,5	5	3,7	blade	SK-050	Fig. 2:f
171			52,5	13,7	4,8	3,6	blade	SK-051	
172			34,7	12,5	3,2	1,9	retouched blade	SK-052	Fig. 2:g
173	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench H; Feature 4/02; 24.07.2002	16,1	13,3	2,4	0,7	blade fragm.	SK-181	
174	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench M, Cutting 11/2006; Feature 1/06 part W; depth 85-95 cm	22,8	31,8	5,4	3,4	flake	SK-182	
175	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench F Cutting 4/2001; Feature 3/01 depth 60-70 cm	26	27	13,8	8,4	core frgm.	SK-183	
176	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench F Cutting 5/2002; Feature 3/01 part S; depth 20-50 cm	30,1	16,5	11	5,9	flake	SK-184	
177	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench M, Cutting 11/2006; Feature 1/06 part W; depth 75-85 cm	31,7	15,3	4,5	2,7	retouched blade	SK-185	Fig. 2:h

178	Moravany 'Stredné pole', Michalovce distr., Slovakia	Trench M, Cutting 11/2006; Feature 1/06 part W; depth 55-65 cm	23,6	29,6	15,3	12,1	core	SK-186	
179	Ražňany-Farské; Sabinov distr., Slovakia	Trench IV/2012 sector C depth 35-45 cm	23	7	3	1	blade fragm.	SK-053	
180			25	15	3	2,3	blade fragm.	SK-054	
181			17,7	14,8	3,4	1	blade fragm.	SK-055	Fig. 2:p
182	Ražňany-Farské; Sabinov distr., Slovakia	Trench IV/2012 Feature 1/2012 sector C depth 60-65	14,7	10,2	2,7	0,3	blade fragm.	SK-056	
183			16,6	19,5	3,2	0,9	flake	SK-057	
184			21,5	20	8,4	3,3	platform rejuvenation flake	SK-058	
185	Ražňany-Farské; Sabinov distr., Slovakia	Trench IV/12 Feature 5; sector C; depth 45 cm	12,3	15,7	2,5	0,3	waste	SK-059	
186	Ražňany-Farské; Sabinov distr., Slovakia	Feature 1/2012 sector D depth 55-60 cm	27	13,4	4,2	1,4	blade fragm.	SK-060	Fig. 2:q

Table 3. EDXRF composition estimates for large obsidian artifacts from Neolithic archaeological sites in Slovakia

Site	Cat. No.	Trace and Rare Earth Element Composition														Ratio	Chemical Type	Illustrated
		Rb	±	Sr	±	Y	±	Zr	±	Nb	±	Ba	±	$Fe_2O_3^T$	±	Fe/Mn		
Slavkovce, Michalovce distr.	SK-081	191	5	58	3	38	3	59	3	7	2	413	22	1,02	0,02	24,8	C1	
	SK-082	179	5	56	3	39	3	57	3	8	2	433	21	nm		25,9	C1	Fig. 2:m
	SK-083	184	5	59	3	31	3	64	3	8	2	458	23	1,03	0,02	26,3	C1	
	SK-084	195	5	61	3	30	3	66	3	7	2	464	21	1,02	0,02	24,4	C1	
	SK-085	190	5	58	3	31	3	60	3	8	2	421	20	nm		24,3	C1	
	SK-086	210	5	59	3	34	3	66	3	7	2	421	21	1,04	0,02	27,1	C1	
	SK-087	198	5	55	3	28	3	61	3	8	2	400	20	nm		24,6	C1	
	SK-088	207	5	73	3	31	3	73	3	9	2	530	22	nm		26,2	C1	
	SK-089	208	5	64	3	34	3	69	3	8	2	405	21	1,16	0,02	24,9	C1	
	SK-090	211	5	72	3	30	3	68	3	9	2	454	22	nm		26,8	C1	Fig. 2:n
	SK-091	191	5	65	3	29	3	63	3	8	2	490	22	nm		24,3	C1	
	SK-092	191	5	59	3	31	3	60	3	8	2	430	20	1,03	0,02	24	C1	
	SK-093	210	5	65	3	34	3	64	3	8	2	493	22	1,18	0,02	24,4	C1	
	SK-094	180	5	57	3	27	3	61	3	8	2	489	22	nm		24,3	C1	
	SK-095	179	5	56	3	30	3	58	3	7	2	437	21	nm		23,9	C1	
	SK-096	209	5	62	3	32	3	60	3	9	2	415	20	1,1	0,02	24,8	C1	Fig. 2:o
	SK-097	200	5	62	3	31	3	66	3	10	2	436	25	1,11	0,02	24,5	C1	
	SK-098	193	5	61	3	32	3	62	3	8	2	460	21	1,01	0,02	24,5	C1	
	SK-099	180	5	60	3	29	3	59	3	8	2	452	22	nm		26,2	C1	
	SK-100	203	5	65	3	31	3	65	3	8	2	447	22	1,13	0,02	23,8	C1	

Malé Raškovce, Michalovce distr.	SK-121	184	4	60	3	28	3	60	4	10	2	393	21	nm		26,8	C1	
	SK-122	173	4	57	3	27	3	58	3	9	2	463	21	nm		27,6	C1	
	SK-124	196	5	65	3	31	3	68	3	8	2	425	21	1,08	0,02	25,5	C1	
	SK-125	197	5	62	3	31	3	62	3	8	2	421	20	1,02	0,02	24,5	C1	Fig. 2:t
	SK-126	184	5	58	3	28	3	60	3	8	2	413	21	1,03	0,02	26,5	C1	
	SK-127	188	5	66	3	31	3	63	3	8	2	444	23	1,09	0,02	25	C1	
	SK-128	199	5	64	3	32	3	63	3	8	2	417	20	1,15	0,02	25	C1	
	SK-129	184	5	63	3	29	3	60	3	8	2	487	22	nm		26,1	C1	Fig. 2:u
	SK-130	200	5	61	3	30	3	64	3	8	2	441	22	1,07	0,02	26,4	C1	
	SK-131	205	5	63	3	32	3	63	3	8	2	389	25	nm		25	C1	
	SK-132	202	5	58	3	31	3	62	3	8	2	427	21	1,1	0,02	25	C1	
	SK-133	203	5	57	3	28	3	56	3	8	2	481	25	nm		26,4	C1	
	SK-134	196	5	58	3	32	3	65	3	10	2	480	23	1,16	0,02	25,2	C1	
	SK-135	188	5	58	3	31	3	66	3	8	2	425	20	1,03	0,02	24,9	C1	
	SK-136	169	4	63	3	38	3	62	3	7	2	478	22	nm		24,4	C1	
	SK-137	200	5	61	3	30	3	63	3	8	2	418	23	1,17	0,02	24,3	C1	
	SK-138	204	5	60	3	31	3	64	3	89	2	385	22	1,17	0,02	23	C1	Fig. 2:v
	SK-139	175	4	60	3	28	3	60	3	9	2	449	21	nm		27,6	C1	
	SK-140	195	5	66	3	28	3	61	3	8	2	417	26	1,16	0,02	25	C1	

Table 3.

Site	Cat. No.	Trace and Rare Earth Element Composition														Ratio	Chemical Type	Illustrated
		Rb	±	Sr	±	Y	±	Zr	±	Nb	±	Ba	±	$Fe_2O_3^T$	±	Fe/Mn		
Zalužice, Michalovce distr.	SK-141	200	5	60	3	31	3	64	3	9	2	415	20	1,05	0,02	24,9	C1	
	SK-142	179	5	71	3	31	3	66	3	8	2	482	22	1,09	0,02	25,6	C1	
	SK-143	168	5	66	3	28	3	63	3	7	2	472	22	nm		26,8	C1	
	SK-144	171	5	64	3	27	3	64	4	7	2	462	21	nm		26,5	C1	
	SK-145	175	5	62	3	26	3	59	3	8	2	432	21	nm		28,5	C1	
	SK-146	205	5	68	3	32	3	66	3	8	2	421	0	nm		23,8	C1	
	SK-147	188	5	56	3	32	3	59	3	8	2	382	20	nm		24,6	C1	Fig. 2:w
	SK-148	195	5	61	3	30	3	60	3	8	2	438	21	1,07	0,02	26	C1	
	SK-149	184	5	59	3	30	3	60	3	8	2	456	21	nm		24,9	C1	
	SK-150	177	5	64	3	28	3	61	3	8	2	500	22	nm		25,8	C1	
	SK-151	207	5	68	3	33	3	70	3	8	2	384	27	nm		24,7	C1	
	SK-152	200	5	55	3	30	3	55	3	7	2	418	28	1,01	0,02	25	C1	Fig. 2:x
	SK-153	192	5	60	3	30	3	63	3	7	2	486	22	nm		25,1	C1	
	SK-154	209	5	57	3	34	3	62	3	8	2	393	20	1,06	0,02	23,1	C1	
	SK-155	184	5	58	3	28	3	58	3	8	2	457	22	nm		24,4	C1	
	SK-156	185	5	66	3	30	3	70	3	8	2	466	22	nm		27,1	C1	
	SK-157	179	5	58	3	30	3	64	3	8	2	444	20	nm		25,6	C1	
	SK-158	190	5	62	3	29	3	63	3	7	2	423	20	1,09	0,02	25,4	C1	
	SK-159	192	5	58	3	31	3	60	3	8	2	431	20	nm		22,7	C1	
	SK-160	180	5	67	3	29	3	66	3	8	2	497	22	1,03	0,02	27,1	C1	

Zbudza, Michalovce distr.	SK-101	206	5	65	3	31	3	67	3	7	2	460	22	1,15	0,02	25,7	C1	
	SK-102	205	5	56	3	31	3	64	3	9	2	383	20	1,12	0,02	22,9	C1	
	SK-103	204	5	66	3	32	3	66	3	9	2	421	21	1,19	0,02	25,9	C1	
	SK-104	170	5	57	3	27	3	60	3	7	2	480	22	nm		24,2	C1	
	SK-105	204	5	62	3	33	3	61	3	8	2	415	20	1,08	0,02	25,1	C1	Fig. 2:i
	SK-106	197	5	62	3	32	3	62	3	9	2	447	20	nm		23,5	C1	
	SK-107	205	5	67	3	36	3	68	3	9	2	391	19	nm		23,7	C1	
	SK-108	191	5	58	3	38	3	64	3	8	2	487	22	nm		24,4	C1	
	SK-109	181	5	63	3	29	3	64		7	2	488	22	nm		24,9	C1	
	SK-110	195	4	55	3	31	3	58	3	7	2	385	20	nm		23,4	C1	
	SK-111	183	5	58	3	30	3	55	3	7	2	385	21	nm		22,5	C1	
	SK-112	191	5	65	3	32	3	66	3	8	2	464	24	1,06	0,02	25,1	C1	Fig. 2:j
	SK-113	190	5	64	3	32	3	66	3	7	2	387	24	nm		24,4	C1	
	SK-114	152	5	69	3	23	3	61	3	8	2	479	21	nm		26,7	C1	Fig. 2:k
	SK-115	186	5	58	3	30	3	57	3	8	2	390	20	nm		23,2	C1	
	SK-116	164	4	67	3	26	3	66	3	6	2	440	21	1,1	0,02	30,3	C1	Fig. 2:l
	SK-117	186	5	60	3	29	3	65	3	8	2	470	22	nm		22,3	C1	
	SK-118	200	5	58	3	31	3	59	3	7	2	399	20	1,04	0,02	22,7	C1	
	SK-119	201	5	63	3	31	3	64	3		2	474	21	1,12	0,02	25,2	C1	
	SK-120	180	4	67	3	29	3	63	3	9	2	475	21	1,11	0,02	26,9	C1	

Table 3.

Site	Cat. No.	Trace and Rare Earth Element Composition														Ratio	Chemical Type	Illustrated
		Rb	±	Sr	±	Y	±	Zr	±	Nb	±	Ba	±	$Fe_2O_3^T$	±	Fe/Mn		
Lúčky, Michalovce distr.	SK-161	181	5	52	3	39	3	57	3	9	2	444	21	nm		24,9	C1	
	SK-162	206	5	66	3	31	3	65	3	8	2	470	21	1,13	0,02	23,1	C1	
	SK-163	204	5	67	3	32	3	63	3	8	2	415	23	1,13	0,03	24,9	C1	
	SK-164	206	5	63	3	32	3	62	3	7	3	380	25	1,07	0,02	25,3	C1	Fig. 2:y
	SK-165	198	5	53	3	31	3	57	3	8	2	387	21	0,95	0,02	23	C1	
	SK-166	204	5	55	3	31	3	59	3	8	2	410	20	nm		25,9	C1	Fig. 2:z
	SK-167	205	5	64	3	33	3	72	3	10	2	398	21	1,15	0,02	24,6	C1	
	SK-168	203	5	63	3	33	3	70	3	9	2	398	21	nm		23,6	C1	
	SK-169	189	5	72	3	29	3	63	3	7	2	422	25	1,15	0,02	28,2	C1	Fig. 2:a’
	SK-170	201	5	63	3	32	3	66	3	8	2	412	20	1,11	0,02	23,9	C1	Fig. 2:b’
	SK-171	172	5	55	3	28	3	58	3	7	2	515	24	nm		23,2	C1	
	SK-172	203	5	66	3	32	3	64	3	8	2	384	21	1,14	0,02	26,1	C1	
	SK-173	196	5	64	3	31	3	61	3	8	2	433	20	1,03	0,02	25	C1	
	SK-174	203	5	64	3	32	3	65	3	9	2	409	22	1,15	0,02	25,4	C1	
	SK-175	185	5	58	3	31	3	60	3	8	2	463	21	0,96	0,02	25,9	C1	
	SK-177	191	5	59	3	30	3	62	3	9		440	21	0,97	0,02	24,2	C1	
	SK-178	179	5	59	3	28	3	59	3	8	2	392	20	0,98	0,02	24,5	C1	
	SK-179	190	5	58	3	30	3	61	3	10	2	396	20	0,98	0,02	24,3	C1	
	SK-180	204	5	75	3	31	3	73	3	6	2	433	20	nm		26,9	C1	

Fintice, Prešov distr.	SK-061	200	5	68	3	30	3	64	3	9	2	425	27	nm		25,7	C1	Fig. 2:r
	SK-062	171	4	64	3	29	3	60	3	8	2	459	21	nm		25,1	C1	
	SK-063	196	5	65	3	30	3	66	3	7	2	422	21	1,17	0,02	24,8	C1	
	SK-064	200	5	65	3	33	3	64	3	8	2	458	21	1,14	0,02	26,2	C1	
	SK-065	205	5	69	3	34	3	67	3	8	2	403	22	nm		25,8	C1	
	SK-066	204	5	64	3	31	3	64	3	9	2	426	20	1,16	0,02	24,9	C1	Fig. 2:s
	SK-067	180	4	60	3	29	3	58	3	9	2	465	23	1,05	0,02	26	C1	
	SK-068	210	5	65	3	32	3	67	3	10	2	425	20	nm		24,5	C1	
	SK-069	204	5	64	3	35	3	69	3	9	2	396	22	1,13	0,02	24,8	C1	
	SK-070	192	5	61	3	29	3	61	3	7	2	423	20	1,11	0,02	26,6	C1	
	SK-071	193	5	59	3	31	3	61	3	8	2	453	21	1,03	0,02	24,7	C1	
	SK-072	191	5	71	3	32	3	67	3	7	2	459	21	1,15	0,02	25,7	C1	
	SK-074	208	5	67	3	31	3	67	3	10	2	435	26	nm		23,5	C1	
	SK-076	189	5	71	3	31	3	62	3	7	2	416	26	nm		26,8	C1	
	SK-077	193	5	60	3	30	3	61	3	7	2	456	21	1,06	0,02	26,2	C1	
	SK-078	203	5	70	3	31	3	63	3	7	2	435	23	nm		27,2	C1	
	SK-079	206	5	60	3	32	3	64	3	7	2	415	21	1,15	0,02	24,7	C1	
	SK-080	210	5	57	3	33	3	70	3	9	2	390	23	1,1	0,02	23,4	C1	

Table 3.

Site	Cat. No.	Trace and Rare Earth Element Composition												$Fe_2O_3^T$	±	Ratio Fe/Mn	Chemical Type	Illustrated
		Rb	±	Sr	±	Y	±	Zr	±	Nb	±	Ba	±					
Moravany 'Stredné pole', Michalovce distr.	SK-001	169	4	68		29	3	60	3	6	2	504	22	1,04	0,02	27,9	C1	
	SK-002	200	5	68	3	32	3	70	3	8	2	448	28	1,05	0,02	26,1	C1	
	SK-003	185	5	57	3	30	3	61	3	9	2	429	21	nm		26,3	C1	
	SK-005	201	5	58	3	33	3	64	3	7	2	384	21	1,07	0,02	23,6	C1	
	SK-006	194	5	63	3	29	3	65	3	8	2	479	22	1,12	0,02	27,4	C1	
	SK-007	199	5	56	3	32	3	62	3	8	2	448	21	1,09	0,02	25,7	C1	
	SK-009	176	5	55	3	28	3	62	3	7	2	438	21	nm		25,8	C1	
	SK-010	204	5	72	3	32	3	68	3	7	2	490	23	nm		26,2	C1	
	SK-011	197	5	66	3	32	3	66	3	8	2	429	21	1,08	0,02	24,4	C1	
	SK-012	205	5	66	3	33	3	70	3	10	2	408	23	1,16	0,02	24,7	C1	
	SK-013	192	5	60	3	31	3	61	3	8	2	440	21	1,02	0,02	24,8	C1	
	SK-014	209	5	64	3	33	3	66	3	7	2	404	21	1,1	0,02	24,5	C1	
	SK-015	193	5	62	3	31	3	61	3	8	2	427	20	1,04	0,02	25,6	C1	
	SK-016	188	5	56	3	31	3	60	3	9	2	451	22	nm		25	C1	
	SK-017	181	4	67	3	3	3	62	3	7	2	415	22	1,02	0,02	27,2	C1	
	SK-018	192	5	63	3	31	3	65	3	7	2	478	21	1,1	0,02	26,6	C1	
	SK-019	194	5	62	3	30	3	63	3	8	2	431	20	1,04	0,02	25,3	C1	
	SK-020	207	5	67	3	32	3	66	3	9	2	459	25	nm		25,8	C1	
	SK-021	199	5	66	3	32	3	66	3	8	2	485	21	nm		27,1	C1	
	SK-022	171	4	65	3	26	3	64	3	8	2	494	23	1,01	0,02	27,3	C1	

Moravany 'Stredné pole', Michalovce distr.	SK-023	185	5	65	3	31	3	68	3	8	2	436	21	nm		24,6	C1	Fig. 2:a
	SK-025	195	5	65	3	30	3	65	3	8	2	448	22	1,09	0,02	25,6	C1	
	SK-026	187	5	61	3	29	3	70	3	10	2	418	21	nm		29,1	C1	Fig. 2:c
	SK-027	191	4	59	3	28	3	60	3	8	2	481	21	nm		26,4	C1	
	SK-028	171	5	64	3	31	3	63	3	6	2	453	20	nm		27,5	C1	
	SK-030	171	5	60	3	26	3	65	3	9	2	463	22	nm			C1	
	SK-031	177	5	67	3	31	3	63	3	7	2	446	20	nm			C1	
	SK-032	192	4	58	3	33	3	58	3	8	2	415	21	1,04	0,02	22,4	C1	Fig. 2:b
	SK-033	197	5	70	3	31	3	64	3	9	2	465	21	1,12	0,02	24,9	C1	
	SK-034	168	4	55	3	29	3	55	3	10	2	468	22	nm			C1	
	SK-035	183	5	57	3	28	3	62	3	8	2	465	22	nm			C1	
	SK-036	176	4	66	3	30	3	63	3	7	2	445	22	nm			C1	Fig. 2:d
	SK-037	183	5	55	3	30	3	59	3	6	2	431	21	nm		23,7	C1	
	SK-039	185	5	59	3	30	3	64	3	8	2	433	21	1,02	0,02	26,4	C1	
	SK-040	183	4	59	3	30	3	60	3	9	2	430	21	nm		22,2	C1	Fig. 2:e
	SK-041	177	4	55	3	28	3	59	3	7	2	455	22	nm		24,1	C1	
	SK-042	183	4	59	3	29	3	64	3	7	2	476	21	nm		23,2	C1	
	SK-043	193	4	57	3	30	3	64	4	8	2	470	24	nm		23,1	C1	
	SK-044	186	3	64	3	29	3	67	3	10	2	457	21	1,07	0,02	25,3	C1	
	SK-045	188	5	72	3	30	3	66	3	8	2	484	21	1,15	0	26,1	C1	
	SK-046	190	5	68	3	32	3	63	3	8	2	522	23	1,08	0,02	25,5	C1	
	SK-047	204	5	71	3	32	3	67	3	9	2	506	22	nm		26,4	C1	
	SK-048	181	4	61	3	28	3	62	3	7	2	488	23	nm		25,6	C1	

Table 3.

Site	Cat. No.	Trace and Rare Earth Element Composition														Ratio	Chemical Type	Illustrated
		Rb	±	Sr	±	Y	±	Zr	±	Nb	±	Ba	±	$Fe_2O_3^T$	±	Fe/Mn		
Moravany 'Stredné pole', Michalovce distr.	SK-049	195	5	59	3	29	3	63	3	8	2	424	20	1,11	0,02	24,8	C1	
	SK-050	203	5	69	3	33	3	69	3	9	2	455	21	nm		26,1	C1	Fig. 2:f
	SK-051	200	5	72	3	32	3	68	3	8	2	420	31	nm		24,8	C1	
	SK-052	201	5	67	3	31	3	66	3	8	2	431	26	1,11	0,02	24,2	C1	Fig. 2:g
	SK-181	200	5	64	3	31	3	64	3	9	2	422	21	1,06	0,02	24,1	C1	
	SK-182	179	4	57	3	27	3	58	3	8	2	427	21	nm		25	C1	
	SK-183	199	5	65	3	31	3	64	3	8	2	523	23	1,16	0,02	24,6	C1	
	SK-184	186	4	71	3	30	3	66	3	8	2	471	21	1,15	0,02	27,6	C1	
	SK-185	176	4	55	3	30	3	55	3	8	2	416	20	nm		25,7	C1	Fig. 2:h
	SK-186	203	5	65	3	31	3	64	3	9	2	467	22	1,16	0,03	27,1	C1	
Ražňany-Farské, Sabinov distr.	SK-053	193	5	59	3	31	3	66	3	9	2	395	23	1,17	0,02	25	C1	
	SK-054	178	5	65	3	28	3	67	3	8	2	464	21	1,03	0,02	26,5	C1	
	SK-057	196	5	60	3	33	3	62	3	8	2	447	20	1,02	0,02	25,3	C1	
	SK-058	178	5	62	3	31	3	66	3	7	2	483	23	1,08	0,02	28,2	C1	
	SK-060	185	5	58	3	31	3	61	3	9	2	447	21	nm		25,2	C1	Fig. 2:q
U.S. Geological Survey Reference Standard																		
RGM-1 (measured)	RGM-1	150	4	111	3	24	3	223	4	8	3	813	23	1.87	.02	65	Glass Mtn., CA	
RGM-1 (recommended)	RGM-1	149		108		25		219		9		807		1.86		nr	Glass Mtn., CA	

Values in parts per million (ppm) except total iron (in weight %) and Fe/Mn intensity ratios; ± = 2-sigma estimate of x-ray counting uncertainty and regression fitting error at 120-360 seconds livetime; nm = not measured; nr= not reported.

Table 4. Integrated Net Peak Intensity Data for small obsidian artifacts from Neolithic archaeological sites in Slovakia

Site	Cat. no.	Intensities/Counts			Σ	Intensity Ratios									Chemical Type	Illustrated
		Rb	Sr	Zr	Rb, Sr, Zr	Rb%	Sr%	Zr%	Fe/Mn	Rb/Sr	Zr/Y	Y/Nb	Zr/Nb	Sr/Y		
Malé Raškovce, Michalovce distr.	SK-123	431	167	233	831	0,519	0,201	0,280	25,7	2,6	2,4	2,8	6,9	1,7	C1	
Lúčky, Michalovce distr.	SK-176	402	146	226	774	0,519	0,189	0,292	26,8	2,8	2,4	3,1	7,3	1,5	C1	
Fintice, Prešov distr.	SK-073	469	167	230	866	0,542	0,193	0,266	23,7	2,8	2,4	3,0	7,2	1,7	C1	
	SK-075	498	164	259	921	0,541	0,178	0,281	24,9	3,0	2,4	3,3	7,9	1,5	C1	
Moravany 'Stredné pole', Michalovce distr.	SK-004	417	154	239	810	0,515	0,190	0,295	27,1	2,7	2,5	2,7	6,8	1,6	C1	
	SK-008	467	145	264	876	0,533	0,166	0,301	27,1	3,2	2,5	3,3	8,3	1,4	C1	
	SK-024	435	128	197	760	0,572	0,168	0,259	25,3	3,4	2,0	2,6	5,2	1,3	C1	
	SK-029	403	144	215	762	0,529	0,189	0,282	25,2	2,8	2,5	2,9	7,2	1,7	C1	
	SK-038	392	162	223	777	0,505	0,209	0,287	26,0	2,4	2,5	2,7	6,8	1,8	C1	
Ražňany-Farské, Sabinov distr.	SK-055	430	177	241	848	0,507	0,209	0,284	27,1	2,4	2,5	2,9	7,3	1,8	C1	Fig. 2:p
	SK-056	380	141	214	735	0,517	0,192	0,291	25,4	2,7	2,6	3,0	7,6	1,7	C1	
	SK-059	438	162	231	831	0,527	0,195	0,278	25,5	2,7	2,3	3,2	7,2	1,6	C1	

Elemental intensities generated at 40 seconds livetime.

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